Between-game variation of physical soccer performance measures in highly trained youth soccer players

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Published in:
Journal of Strength and Conditioning Research

DOI:
10.1519/JSC.0000000000002132

Published: 31/07/2019

Document Version
Peer reviewed version

DOI: 10.1519/JSC.0000000000002132

Title: Game to game variation of measures of physical soccer performance in a group of highly trained youth soccer players.

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Abstract

To assess the between-game variation in measures of physical performance during 11 v 11 soccer match-play, over a short period of time, in highly trained youth soccer players. A single cohort observational study design was employed. Physical match performance data were collected from 17 male, highly trained youth soccer players (age: 13.3 ± 0.4 y) over three, 2 x 20min, 11 v 11 matches. Using 10 Hz GPS, the variables selected for analyses were total distance (TD), high-speed running (HSR), very high-speed running (VHSR), number of high-speed running efforts (HSReff) and number of very high-speed running efforts (VHSReff). Match data was also separated into cumulative 5 min epochs, to identify the peak 5 min epoch and the mean of the cumulative 5 min epochs for each match. Variability was quantified using the coefficient of variation (CV), Standard error of measurement (SEM) and intra-class correlation coefficient (ICC). Between- and within-player smallest worthwhile changes (SWC) were also calculated for each variable to aid in the interpretation of the data. Analysis of the variance between games reported a low CV for TD (3.8%) but larger CVs for HSR (33.3%), HSReff (35.4%) and VHSR and VHSReff (59.6 and 57.4 %, respectively). Analysis of 5 min epochs (peak and average) found an increase in the CVs beyond that of the values reported for the whole match. Between-player SWC in high intensity physical performance data ranged from 24.7 – 42.4 %, whereas within-player SWC ranged from 1.2 – 79.9%. The between-game variability of high and very high intensity activities in youth soccer players, across three soccer matches over a short period of time (2 weeks), is relatively 'large' and specific to the individual, thus highlighting the need for caution when interpreting physical performance data between games and players.

Keywords: Match-play; reliability; variation; GPS analysis; youth soccer

INTRODUCTION

Since the introduction and implementation of Global Positioning Systems (GPS) into portable athlete tracking micro-technology, there has been an increase in the volume of scientific literature examining ‘performance’ and training load in team sports (1, 15, 27). The development of such technology has enabled both researchers and practitioners to assess match activity profiles at all levels, including youth soccer (12, 13). Yet, despite the increase in the use of this technology, there appears to be a lack of research and focus on the between-game variance within the GPS derived variables. In particular, many studies often neglect to mention or acknowledge the impact of natural variation between games (or session-to-session) within their discussions (19). Failure to acknowledge the variation within such methodologies could greatly affect the interpretation, and therefore the practical implications, of the data and results. For example, without an appreciation for the short-term, between-game variance, practitioners will be unable to identify whether or not a periodized mesocycle is having a positive effect on physical performance or if players’ physical performance during match-play is subject to accumulated fatigue (i.e. overtraining).

Team sports performance is stochastic and unpredictable in nature (2), meaning that the between-game variation is inherent. In competition, the resultant impact of the opposing team (17), phase of the season (19, 27), weather conditions, substitutions, context of the match (win/lose margin) and current form (6) are all likely to have an influence on players’ physical performance. Similarly, the number of games analysed will also impact upon the between-game variability, with longer periods of data collection (e.g. a season) demonstrating reduced levels of between-game variability (19, 28). Consequently, an increased appreciation for the between-game variability which is evident during soccer match-play, may begin to allow practitioners and coaches to understand the level of variance that is evident during youth soccer match-play. Thus, allowing them to identify when 'worthwhile' or 'detectable' changes are apparent within players' levels of physical performance.

The variability of physical performance measures have previously been reported for adult populations across a range of football codes including, soccer (19), rugby league (28) and Australian Rules Football (26). From this research it is evident that high intensity activities display high levels of between game variance, with Gregson et al. (19) reporting a coefficient of variations (CVs) of 16.2% ± 6.4% for distances covered at an intensity between 19.8 and 25.2 km/h, and Kempton et al. (26) reporting high within-player variability for high (>14.4 km/h; CV = 11.7-13.8%) and very high-speed running (>19.9 km/h; CV = 15.1-20.9%) between multiple matches. Within the study of Kempton et al. (26) practical application of the data was supported by calculating the smallest worthwhile change (SWC) for each of the measured variables. This provides a measure for which practitioners can use to assess the magnitude of the between-game difference in a measure of physical performance, and therefore if it is 'worthwhile' and if so, to what extent (23). This will enable practitioners to assess if there is a difference beyond that of the measured variance, be it positive or negative.

Despite this, there have yet to be any attempts to assess the between-game variability in measures of physical performance in highly trained youth soccer players. Previous studies have tended to focus on the observed variability during small sided games in youth soccer (20, 21), rather than during 11 v 11 (as in competition) soccer match-play. This is surprising, when considering the plethora of research which has attempted to evaluate physical performance during competitive youth soccer match-play (10, 11, 12), along with the added issues of growth and maturation in youth populations. Indeed, growth and development is likely to influence players' physical output capabilities and the inherent heterogeneity in growth and maturation, within any cohort of similar aged youth soccer players, is also likely to lead to inter-individual variance in both players' physical and metabolic capacities. Without an understanding of the apparent variation within measures of physical performance during match-play, those practitioners working with youth soccer players will be unable to identify the extent to which physical performance has truly been affected by fatigue, growth and maturation and talent development regimes.

Consequently, the quantification of the variance within physical performance measures during match-play over a short period of time (2 weeks), in highly trained youth soccer players, may aid in the analysis, interpretation and practical inference of such data by establishing reference values for the SWC in the outcome measures. Therefore, the aim of the present study was to assess the between-game variation in measures of physical performance during 11 v 11 soccer match-play over a short period of time (2 weeks), in highly trained youth soccer players.

METHODS

Experimental Approach to the Problem

Data collection was conducted on three separate 11 v 11 matches, with each match being completed on a separate day following a minimum of 5 days between each match. As such, data collection was undertaken over a 2 week period during the end of a 6 week pre-season training phase. Following initial screening processes, players were involved in three, 11 v 11 matches (excluding goalkeepers), which were conducted during training. Matches were comprised of 2 x 20 min halves, with a 5 min rest interval in between halves. Players' match activities were monitored and analysed using 10 Hz global positioning systems (GPS;

Catapult, Melbourne, Australia). All testing procedures were preceded by a 10 min warm-up, consisting of low intensity running, dynamic stretching and then moderate intensity running. Following all matches a 5 min cool down, consisting of low intensity running and static stretching, was conducted.

Subjects

To assess the between-game variation of multiple GPS derived measures obtained during 3 soccer matches, 17 highly trained youth soccer players volunteered to participate (5 defenders, 6 midfielders and 6 attackers, with both teams adopting a 4-3-3 formation in each match). As there were only 17 outfield players recruited for the present study, 3 additional outfield players and 2 goalkeepers were used to make up the numbers. As these players did not provide assent (or parental consent), at no point, was any data obtained or analysed in respect to these players and the 11 v 11 matches were simply part of their weekly training within the Academy. All participants were outfield players, aged between 12 and 14 years and from the same Category One Premier League Football Academy. Table 1 displays all anthropometric and screening measures of the players. Maturity status was quantified using self-assessment, Tanner Stage method (35) and maturity offset (29). Ethical approval was granted from an Institutional Ethics Board and all participants, and their parents, were informed of the benefits and risks of the investigation prior to signing an institutionally approved informed consent document to participate in the study. As all participants were under the age of 18, both players and their parents were informed about all procedures and requirements of being involved in the study, before providing written informed assent and consent from participants and parents, respectively.

*****Insert Table 1 About Here*****

Procedures

Each match was conducted on the same third generation artificial pitch with the same dimensions (90 x 50 m) and at the same time of day in clear and dry conditions with minimal wind (Averages for temperature, humidity and pressure corresponded to 19.8 ± 2.4 ºC, 59.0 ± 3.4 % and 1009 ± 1 mmHg, respectively over the three matches). Matches were comprised of 2 x 20 min halves with a 5 min rest interval between halves with no coaching or external encouragement provided during each match. The composition of the teams and positions remained the same for all three matches, with each participant assigned their own GPS for all matches. Matches were performed on three separate occasions with a minimum of 48 hrs between matches.

The GPS unit was fitted in a purpose made, size appropriate vest between the scapulae of each player. Units were turned on 10 min prior to the warm-up so that an appropriate signal was obtained prior to data collection. The mean number of satellites during data collection were 8.0 ± 0.5, 8.3 ± 0.4 and 8.2 ± 0.6 for matches 1, 2 and 3 respectively. Furthermore, the mean horizontal dilution of position (HDOP), which is a reflection of the accuracy and quality of the signal were 1.45 ± 0.25, 1.31 ± 0.11 and 1.31 ± 0.08 for matches 1, 2 and 3 respectively. HDOP values can range between 1 and 50 and an ideal HDOP value of 1 indicates that 1 satellite is above with the remainder equally spaced around the horizon (25). Finally, at all times an 'open' sky was present and there were no obstructions, ensuring clarity for satellite acquisition.

Following each match, the GPS data was downloaded and analysed using Catapult Software (Catapult Sprint v5.1.0, Melbourne, Australia) and specially designed Microsoft Excel spreadsheets. Data was recorded for the whole match, each 20 min half and into successive 5 min epochs (e.g. 0 – 5 min, 1 – 6 min, 2 – 7 min, 3 – 8 min, etc.), to establish and quantify the peak 5 min epoch and the mean of the cumulative 5 min epochs throughout each match. This process is similar to that which has been adopted in previous research (7, 8), when identifying the most intense 5 min period of match-play. In previous research, however, discrete 5 min periods have been employed (0-5 min, 5-10 min, etc.) as opposed to successive 5 min epochs. Information recorded included total distance (TD), metres per min (m/min), relative high speed running distance (HSR), relative high speed efforts (HSReff), relative very high speed running distance (VHSR), relative very high speed efforts (VHSReff) and relative sprint distance (S). To obtain 'relative' measures players' maximal linear velocity was assessed and obtained on a separate occasion prior to the first match. Maximal linear velocity was defined as the maximal velocity obtained during a 20 m straight line sprint from a standing start and obtained from the individual GPS devices, which were then used to record the individual player's physical performance during soccer match-play. Relative HSR running was regarded as distance covered above 50% of maximal linear velocity, relative VHSR was regarded as any distance covered above 70% of maximal linear velocity and relative Sprint as anything above 90% maximal linear velocity. The same thresholds were used for HSReff and VHSReff and an effort was regarded as any occurrence when such a speed was attained and sustained for greater than 0.2 s.

Statistical Analysis

To assess the between-game variation in GPS derived variables across the three soccer matches, results from the three trials were recorded and analysed, generating a coefficient of variation (CV) and a Standard error of measurement (SEM) and a relative measure of reliability an intraclass correlation of coefficient (ICC). These measures of reliability were employed as; 1) CVs provide a dimensionless percentage, allowing the reliability of different performance measures to be compared, 2) SEMs provide an indication of the dispersion of the measurement error within a given performance measure, and 3) ICCs provide a measure of relative reliability to assess the stability (rank order) of a group, across repeat trials (3, 32). Firstly, an assessment of the data for heteroscedascity was performed, by formally plotting the absolute difference against the means and calculating the correlation coefficient between units (3). Levels of heteroscedascity were shown to be minimal and were only slightly reduced when the data was log-transformed, however, due to the inability to log transform a '0' value and the occurrence of '0' values for some players within the domain of VHSR, the data was not log transformed and the analysis was performed on the original raw data.

In the absence of a learning effect an overall SEM was calculated by square rooting the mean square error of a one-way within subjects ANOVA. A group CV (between-player) was calculated by using the 'crude' equation of (SEM/Overall Mean) x 100 (5). Individual (within-player) CVs were calculated by dividing the standard deviation of an individual's repeated performances by the corresponding mean value (22). Finally, an ICC was calculated using the Shrout and Fleiss, ICC 3, 1 formula (36). Furthermore, to aid interpretation, a smallest worthwhile change (SWC) was calculated for within- and between-player variations. The SWC was calculated as a magnitude of 0.5 of the within-player variations (0.5 x individual CVs) and as 0.5 of between-player variations (0.5 x between-player SD) (23, 26, 28). Analysis of the data was aided using the Hopkins (2011) Excel Spreadsheet and the guidance provided by Batterham and George (5). All statistical analyses were performed using SPSS version 21.0 (IBM SPSS statistics for Windows, IBM, Armonk, New York) and Microsoft Excel (Microsoft Excel 2013, Microsoft, Redmond, Washington).

RESULTS

All players were able to compete for the full duration of the 3 separate matches employed within the study. Examination of the means and standard deviations across the three trials, using repeated measures ANOVAs, did not reveal any evidence of a learning effect or signs of systematic bias (P >0.05), as can be seen in the variance within the trends across the 3 matches between TD, HSR and VHSR (Table 1). As a result measures of reliability were obtained by assessing the variance across the three trials. Table 1A, 1B and 1C display the between-game variation in GPS derived variables over the 3 soccer matches for the whole match, the peak 5 min epoch and the mean of the cumulative 5 min epochs throughout each match, respectively.

*****Insert Table 2 About Here*****

According to the group CVs, Total Distance (TD) covered demonstrated the least amount of variance between games but as the intensity of the movement increases so does the variance within the measurement, with measurements of HSR and HSR efforts presenting CVs ranging from 33.3 – 42.8 % and measurements of VHSR and VHSR efforts presenting CVs ranging from 57.4 – 79.7 %. This is highlighted in Figure 1, where individual players' physical performance in measures of TD display less fluctuation compared to measures of HSR, across the three games.

*****Insert Fig 1 About Here*****

Finally, a wide range of values were presented for the within-player SWC (Table 2). Figure 2 presents a comparison of within-player variation between two players, in measures of HSR. Despite a similar average value for measures of HSR across the 3 games, player 10 is shown to display higher levels of within-player variation compared to player 9, thus highlighting the greater levels of between-game variation in player 10 within this measure (HSR) of physical performance.

Insert Fig 2 About Here

Discussion

Present results reveal, when expressed relatively either as a CV or as a SWC, that TD was the most stable GPS derived measure during soccer match-play in highly trained youth soccer players, whether it be the whole match, a peak 5 min period or the mean average of cumulative 5 min epochs. Results also demonstrate, the more intense the action (in both distance covered and efforts performed) the greater the between-game variation, with measures of VHSR (distance and efforts) showing the greatest amounts of variance between games.

The levels of variance presented for TD within the present study, for the whole match and mean of the cumulative 5 min epochs, are in agreement with those of Coutts and Duffield (14) and McLaren et al. (28). Coutts and Duffield (14) employed a standardized, simulated team sport running circuit to assess the reliability (technical error) in a range of 1 Hz GPS devices and reported intra-unit CVs that ranged from 4.0 – 7.2 %. However, the applicability of these findings to the current results are questionable due to the standardized nature of the task employed within the Coutts & Duffield (14) study and the faster sampling rate of the GPS used (10 Hz) in the present study. Conversely, the study by McLaren et al. (28) assessed the variance in measures of physical performance during competitive adult team sports match-play. McLaren et al. (28) reported a within player CV of 10.0 ± 2.1 % and a between player CV of 5.5 ± 1.5 % for TD covered during rugby union competitive match-play, over 15 matches.

The relative stability shown within the measures of TD covered during soccer match-play provides support for the use of TD as a measure for monitoring physical performance in youth team sports players (24). Although, while the quantification of TD covered can be a useful measure for monitoring training load, and therefore risk of overtraining within soccer players (24). Measures of TD are not recognised as an appropriate measure for evaluating a player's or team's physical performance during match-play (7, 30). This is due to its inability to distinguish between playing level and therefore levels of physical performance (30). Rather, measures relating to high intensity activity (e.g. HSR and VHSR) have been shown to distinguish between playing level, with elite level players performing more high intensity activities when compared to their untrained counterparts (30). Consequently, measures of high intensity activity, not TD covered, are commonly used as an indicator of physical performance within soccer match-play.

With respect to between-game variance, the current values presented for measures of high and very high intensity activities (HSR, VHSR, HSReff and VHSReff), however, are larger than those previously reported within the literature (14, 28, 33). Rampinini et al. (33) reported CVs of 4.7% and 10.5% for HSR and VHSR activities, respectively, when using 10 Hz GPS devices, whereas Coutts and Duffield (14) reported CVs of 11.2 - 32.4% and 11.5 – 30.4% for high and very high intensity running, respectively, across a range of different GPS devices. However, the methods adopted within both these studies required the participants to complete a standardized course rather than assess them during competitive soccer match-play.

Competitive soccer match-play is random and unpredictable, meaning that the variance in the activities and intensities between games is more diverse than that which is experienced during standardized drills. Furthermore the likely higher levels of intrinsic variability (Physical, tactical and technical immaturity) within youth soccer players also contributes to the existing levels of high variance, which have already been demonstrated within competitive adult team sports (19, 28). The potential presence for further variance within youth players' physical, technical and tactical maturity is likely to exacerbate the heterogeneity within locomotor characteristics, and therefore between-game variance, within youth soccer match-play. Consequently, the culmination of high levels of intrinsic variability and extrinsic variability are likely to result in even larger levels of between-game variance, as demonstrated within the present study.

Using a large sample size of professional adult soccer players (n = 485), Gregson et al. (19) assessed the variation in physical performance during competitive matches over a long (a season) and short (8 week) term period. These authors reported a CV of 17.7 ± 6.8% and 23.5 ± 21.8 % for total high speed running (>19.8 km/h), over a long and short term, respectively. The larger standard deviation evident in the short term, total high speed running, within the study of Gregson et al. (19) supports the large variation evident within the present study, which is prevalent in soccer match-play over a short period of time. Consequently, the evidence suggests that the variation between games, in measures of physical performance, increases as the period of data collection decreases, a theory which would be substantiated by the current results which were collected over a period of 2 weeks. Although in elite rugby union players, McLaren et al. (28) conducted a similar study which assessed the variability in measures of physical performance across 15 competitive matches. McLaren et al. (28) reported within-player CVs of 27.6 ± 6.9 and 68 ± 19%, and between-player CVs of 16.5 ± 5.1 and 58 ± 63 for measures of HSR and VHSR, respectively. While current results present a larger level of variance than those reported by McLaren et al. (28), it appears that the assessment of physical performance during competitive team sports results in a substantial increase in the between-game variance in both high and very high intensity activities, with larger variances apparent across shorter time periods and in higher intensity domains. Furthermore, the positional variance, in terms of physical performance, within soccer is arguably more diverse than rugby union.

The ICCs show reduced values for the peak 5 min epochs and cumulative 5 min epochs, when compared to the ICCs for data from the whole matches. While the ICC is employed as a common statistical method for assessing the reliability of a measure, it is dependent on the stability to which a particular measure holds it position within the sample, across repeat tests and is therefore dependent upon the sample heterogeneity, unlike CV (5). This means that the greater the spread of the scores or range within the measured variable, the greater the magnitude of the ICC (5). Consequently, the reduced ICCs within the peak 5 min epochs and cumulative 5 min epochs are likely to be a result of the greater homogeneity within the sample, and as such may not be an appropriate measure of reliability to use when analysing physical performance within a group of highly trained soccer players. Although, CVs for measures of physical performance within the peak and mean of cumulative 5 min epochs do provide further evidence to suggest that the levels of variance are greater when analysing the data in these predefined epochs. Consequently, researchers and practitioners should be aware of the potentially increased variance when analysing performance data in smaller epochs, particularly as this will have an impact upon the interpretations of the results.

Current findings demonstrate large differences in the smallest worthwhile changes (SWC) in physical performance data, from one game to another. Data also supports previous findings that show that as the intensity increases so does the range in the within SWC (%) variation (19, 26, 28), a finding which is likely associated with, but not limited to, the reduced reliability of measurement devices at higher velocities, demonstrated during standardized running drills (14, 15). When examining the within-athlete SWC, it is clear to see that there is a large variation among players with regards to what would be considered as a 'worthwhile' effect between matches. For example, the within-player SWC ranged from 1.2 – 46.9 % for HSR (during a whole match), this suggests that there are substantial inter-individual differences in between-game variations, with regards to what would be noted as a 'worthwhile' change (Fig 2). Such differences maybe a consequence of position (e.g. defenders vs. midfielders vs. attackers), as some positions may result in a greater amount of between-game variance (e.g. wingers involvement in a game may vary more compared to a centre midfielder) (26). Consequently, there is a need to be aware of what is regarded as a 'worthwhile' change for each individual, particularly as the present results seem to suggest that a group SWC could result in incorrect interpretations of players' performance, which could then have a subsequent impact upon training practices and periodization.

It is important to note however, it is not the absolute level of variance which is of sole importance, rather, it is the magnitude of the 'noise' compared to both the usually observed changes (signal) and the changes that may have a practical effect (9). Moreover, the calculation of the appropriate magnitude for the SWC within measures of physical performance in team sports (which are not categorical measures of success) is less straightforward. This is due to the fact that there is no current evidence to demonstrate that changes greater than any fraction of the between-athlete standard deviation or the individual

CV are meaningful in practice (9). Nevertheless, the utilisation of such a measure provides researchers and practitioners with data that can be employed to make a more informed decision about the physical performance of the players, either as a group (team) or on an individual basis (23). To date, similar research has adopted the magnitude of 0.2 when calculating the SWC in measures for team sports performance (26, 28), however, due to the observed variance which is clearly evident in competitive soccer match-play, a larger magnitude of 0.5 may provide those analysing the data with more confidence when deciding whether or not a change is 'worthwhile'. Consequently, there is a necessity for those involved in team sports to understand the level of variance and sensitivity that is apparent within physical performance data during competition and within the time period that is being assessed (context-specific). This will allow sports practitioners and researchers to evaluate if any observed differences, from one game to another are meaningful.

The current sample size is substantially lower than those within the literature which have examined the variability of physical performance data over a longer period of time (19, 28). The aim of the current study, however, was to assess the variability in physical performance data over a short-period of time (2 weeks), providing thresholds and context specific data, which can be utilised to see if there has been an effect on players' physical performance during competition over a similar period of time (i.e. from week-to-week) or between players. Furthermore, limitations regarding the cumulative 5 min match splits (0-5, 1-6, 2-7 min, etc.) and the calculation of the mean of the cumulative 5 min epochs should be recognised. The current method of 'splitting' the data is viewed as a more sophisticated method than the use of discrete 5 min epochs (0-5, 5-10 min, etc.), employed in previous research (7, 8), for the identification of the 'peak' 5 min epoch. The current results, however, provide a starting point and a framework for the understanding, analysis and interpretation of the variability in physical performance data during soccer match-play. Finally, the current match conditions aimed to negate the influence of extraneous variables, such as opposing team, playing conditions and external encouragement. The impact, however, of environmental conditions, live score difference (win/loss margin), player proximity to the ball, as well as the magnitude and frequency of other technical and tactical actions all have the potential to influence the variability of physical performance data. These measures, however, were beyond the scope of the present study. The quantification and exploration of the contribution of these extraneous variables to the between-game variability would further enhance our understanding of match-play variability.

With the development in micro-technology (GPS) and its common use for assessing physical performance in competition, there is a need to understand the level of variance in the information provided, in a context-specific manner (e.g. youth soccer match-play). Current results demonstrate that the between-game variation across three youth soccer matches, over a short period of time, is substantially larger than values previously reported in the literature. Within-player variations, however, appear to demonstrate large differences between players, a finding which may be a consequence of player characteristics, positional demands, tactical roles and fitness levels. The present findings highlight the difficulties associated with both the interpretation of GPS derived variables (i.e. physical performance) and also the use and application of measures of high and very high intensity activities as indicators of performance. Finally, practitioners should be aware of the potentially large levels of between-game variance within youth soccer match-play, as this is likely to have implications for training practices, interpretation of measures of physical performance, training periodization and potentially talent identification.

PRACTICAL APPLICATIONS

The current study provides a process which may be particularly useful for those involved in the prescription of training programmes, talent identification and monitoring of both training load and performance. For example, in the current data set (for a whole match) a between-athlete SWC of 17.6% was calculated for HSR, this demonstrates the large changes in measures of physical performance which are necessary to be regarded as a meaningful difference among a group of highly trained youth soccer players, when assessing performances within a short period of time (across 2 weeks), which has implications for the interpretation of performance measures which are increasingly obtained within elite level youth soccer. In contrast, however, the within SWC (%) present a potentially different approach to analysing physical performance within youth soccer players, on an individual level. Present data suggests that the 'within-athlete' SWC may be substantially lower than the 'between-athlete' SWC for some individuals. As a result the assessment and calculation of within-athlete SWC (individual variations) for each player will allow sports practitioners and researchers to assess the between-game variability on an individual level. This approach may have particular relevance within the domain of talent development. Indeed, a practical goal may be to maintain a player's level of physical performance but reduce the amount of variance within their physical performance, thus making their levels of physical performance more consistent. Moreover, practitioners may wish to monitor the extent to which a particular training mesocycle has impacted upon a player's physical performance or examine the extent to which growth and maturation is impacting upon a player's physical performance during match-play. Consequently, applied sports practitioners and researchers should examine the extent of the between-game variation and SWC in their own cohort of players and in each of the relevant performance measures. This should be done both as a team and individually and, if data permits, on a positional level.

Acknowledgements

We would like to thank all the participants involved in the study for their committed participation in the project.

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Fig 1: Individual players' values and the group mean for total distance (TD) and high speed running (HSR) for each of the three matches.

Fig 2: A comparison between two players (midfielders) for high speed running across the three matches and between the respective player's coefficient of variation (CV) and smallest worthwhile change (SWC).

Table 1: Anthropometric and screening measures of the players (*n*=17).

Variable	Mean ± Standard Deviation	95% Confidence Intervals
Age (y)	13.3 ± 0.4	13.1 - 13.5
Stature (m)	1.59 ± 0.11	1.54 - 1.64
Body Mass (Kg)	48.9 ± 10.1	43.9 - 53.9
Maturity Offset (y)	-0.8 ± 0.9	-1.2 to 0.3
Σ4 Skinfolds (mm)	30.7 ± 5.1	28.3 - 33.1
Tanner Stage	3 ± 1	2 - 3
Training Years (y)	4.4 ± 2.1	3.4 - 5.3
Training Hours (hrs.p.week)	12.4 ± 2.3	11.3 - 13.5

Note: Skinfolds used for the Σ 4 skinfolds were the biceps, triceps, subscapular and superilliac (Durnin & Womersley, 1974).

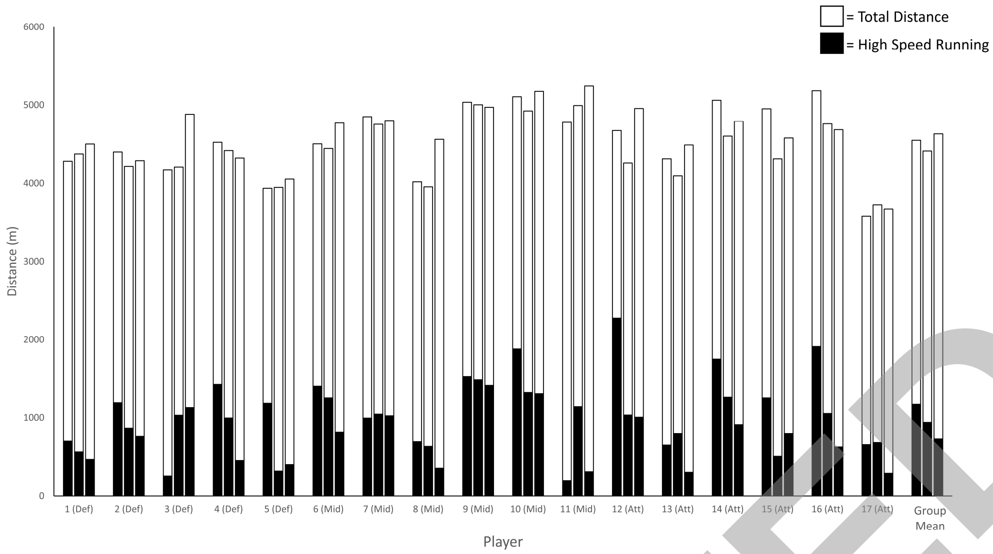
Table 2: Game-to-game variation from GPS derived variables (95% Confidence Intervals) during 3 sterile soccer matches for A) the whole match B) the peak 5 min epoch and C) the mean of the cumulative 5 min epochs throughout each match.

A	Match 1	Match 2	Match 3	Mean	SD	ICC	SEM (m)	CV (%)	SWC Between (%)	SWC Within (%)
TD (m)	4553	4412	4634	4533	418	0.85 (0.71 - 0.93)	171 (142 - 230)	3.8 (3.0 - 5.4)	2	0.3 – 4.5
HSR (m)	1174	942	728	948	472	0.52 (0.24 - 0.74)	316 (262 - 424)	33.3 (26.1 – 46.0)	17.6	1.2 – 46.9
VHSR (m)	81	193	107	127	107	0.43 (0.61 - 0.39)	75 (62 - 101)	59.6 (46.7 - 82.3)	30.7	5.6 – 78.0
HSR efforts (n)	87.4	59.4	53.4	66.7	31.1	0.36 (0.06 - 0.64)	24 (20 - 32)	35.4 (27.7 - 48.8)	14.7	3.4 – 44.2
VHSR efforts (n)	5.5	12.8	7.6	8.6	6.9	0.40 (0.10 - 0.66)	5 (4 - 7)	57.4 (45.0 - 79.2)	29.0	3.9 – 79.9

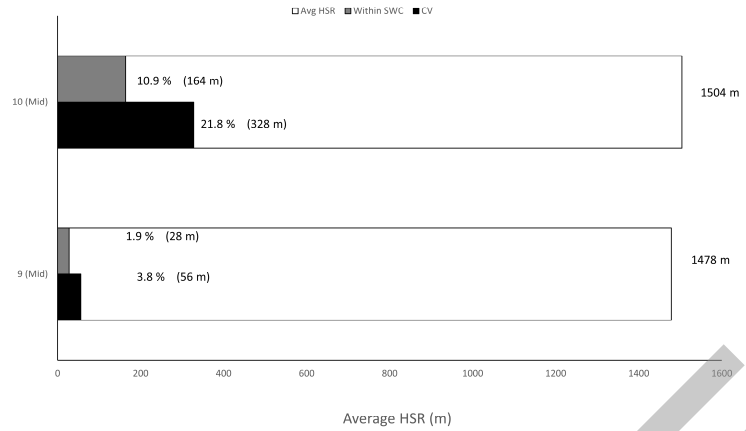
B	Match 1	Match 2	Match 3	Mean	SD	ICC	SEM (m)	CV (%)	SWC Between (%)	SWC Within (%)
TD (m)	624	632	647	634	80	0.23 (-0.06 - 0.54)	71 (59 - 96)	11.2 (8.8 - 15.5)	4.2	0.7 – 14.6
HSR (m)	136	190	154	160	70	0.40 (0.11 - 0.67)	53 (44 - 71)	33.2 (26.0 - 45.8)	15.3	1.9 – 37.4
VHSR (m)	25	47	29	33	29	0.30 (0.00 - 0.59)	24 (20 - 32)	72.1 (56.6 - 99.5)	26.7	9.3 – 86.6
HSR efforts (n)	22	31	24	26	10	0.36 (0.06 - 0.63)	8 (7 - 11)	31.4 (24.6 - 43.3)	14.4	1.1 – 31.7
VHSR efforts (n)	4	8	5	6	5	0.32 (0.02 - 0.61)	5 (3 – 6)	71.4 (56.0 - 98.5)	26.7	6.2 – 88.6

C	Match 1	Match 2	Match 3	Mean	SD	ICC	SEM (m)	CV (%)	SWC Between (%)	SWC Within (%)
TD (m)	559	537	569	555	49	0.81 (0.65 - 0.91)	22 (18 - 30)	4.0 (3.1 – 5.5)	2.2	0.4 – 4.7
HSR (m)	69	102	77	83	40	0.33 (0.03 - 0.61)	31 (26 - 42)	37.5 (29.4 - 51.8)	16.3	3.8 – 52.1
VHSR (m)	8	21	12	14	13	0.15 (-0.13 - 0.47)	11 (9 - 15)	78.1 (61.2 - 107.8)	34.3	7.1 – 86.6
HSR efforts (n)	13	19	12	15	7	0.21 (-0.06 - 0.52)	6 (5 - 8)	42.8 (33.6 - 59.1)	18.6	3.3 – 53.1
VHSR efforts (n)	2	4	2	3	2	0.14 (-0.15 - 0.45)	2 (1 - 3)	79.7 (62.5 - 110.0)	36.0	8.5 – 86.6

Note: SD =Standard Deviation: ICC =Intraclass Correlation Coefficient: SEM =Standard Error of Measurement: CV =Coefficient of Variation: SWC =Smallest Worthwhile Change.



= Total Distance
= High Speed Running
Distance (m)
6000
5000
4000
3000
2000
1000
0
1 (Def)
2 (Def)
3 (Def)
4 (Def)
5 (Def)
6 (Mid)
7 (Mid)
8 (Mid)
9 (Mid)
10 (Mid)
11 (Mid)
12 (Att)
13 (Att)
14 (Att)
15 (Att)
16 (Att)
17 (Att)
Group Mean
Player



Avg HSR
Within SWC
CV
10 (Mid)
10.9 % (164 m)
21.8 % (328 m)
1504 m
9 (Mid)
1.9 % (28 m)
3.8 % (56 m)
1478 m
0
200
400
600
800
1000
1200
1400
1600
Average HSR (m)